

Testosterone, Dominance, and Aggression

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Dominance

- Dominance: Establishing and maintaining status or rank over others
- Social rank within a dominance hierarchy

Dominance Hierarchies

- Types of dominance hierarchies:
 - Linear: A dominates everyone, B dominates everyone but A, C dominates everyone but A and B, and so on
 - Circular: A dominates B, who dominates C, who dominates A
 - Cooperative/Coalitional: A dominates B, but only with the help of C

Dominance Hierarchies

- Hierarchies develop for two reasons:
 1. Inequalities amongst individuals in securing resources
 2. Establishing this inequality consumes time and energy
 - More efficient to establish a set hierarchy

Aggression

- Aggression: “[An] overt behavior with the intention of inflicting damage or other unpleasantness on another individual.” (Nelson, 2005 p. 470)
- Important behavior for attaining and maintaining high social rank
- Not only way to attain rank, but common and important one

Neural Systems Related to Aggression

- Neural structures include:

prefrontal cortex

amygdala

hippocampus

medial preoptic area

hypothalamus

anterior cingulate cortex

insular cortex

ventral striatum

- Emotion and Violence? (Davidson, 2000)

Testosterone, its metabolites, & aggression

Androgen responsive – either testosterone or T
metabolized into DHT

Estrogen responsive – T aromatized into estradiol

Synergistic pathway – responding to both androgens
and estrogens

Direct T pathway – only responds to T, not its
metabolites

Metabolites and Aggression

White-throated sparrows during non-breeding season

- Sparrows treated with either T, DHT, or estradiol
 - Only T-treated birds increased in aggression
 - DHT, estradiol, and controls did not change
- Sparrows treated with either T, DHT+estradiol, DHT, or estradiol
 - Both T and DHT+estradiol increased in aggression
 - DHT, estradiol, and controls did not change

(Archawaranon & Wiley, 1988)

Role of Serotonin

- Serotonin acting on receptor subtypes 5-HT_{1A} and 5-HT_{1B} inhibits aggression
(i.e. high activation of these receptors leads to low aggression)
- Rats engaging in competition over sugar pellets
 - When treated with testosterone propionate (TPR), rats became dominant over competitor
 - When TPR-treated rats were given 5-HT_{1A} and 5-HT_{1B} agonists, they became non-dominant

(Bonson, Johnson, Fiorella, Rabin, & Winter, 1994)

Challenge Hypothesis

- Testosterone will be elevated during certain critical periods, such as mating season, in order to facilitate aggressive behavior during moments of high competition
- Originally developed to explain male mating behaviors in birds (Wingfield, et al., 1990)
- Has since been applied to other species (e.g. Baboons – Beehner, et al., 2006; Possums – Wehi, et al., 2006)
- Found to be more pronounced in monogamous species than promiscuous species (Hirschenhauser & Oliveira, 2006)

Challenge Hypothesis

- Seasonal Changes (e.g. mating season)
- Stable v. Unstable Hierarchies
(e.g. hierarchy formation)

Seasonal Changes

- Red Deer
 - Castration of stags caused decrease in social rank
 - Loss of rank due to loss of antlers
 - During winter (when other males lose antlers naturally) castrated males could regain some status
 - Stags implanted with T during summer regained some status
 - Increased in aggression prior to antler growth (could not regain full status due to lack of antlers)
- Testosterone promotes dominance via increases in aggression and increases ability to follow through with that aggression (e.g. antlers)

Stable v. Unstable Hierarchies

- T is related to dominance, rank, and aggression during times of instability
 - Unstable hierarchies
 - Dominance challenges
 - Hierarchy formation

Stable v. Unstable Hierarchies

- T and aggression were not correlated during times of stability in male chacma baboons, but were correlated during times of hierarchy instability (i.e. high ranks were being actively contested)
- Controlling for age, T was unrelated to current rank, but predicted future rank

(Beehner, et al., 2006)

Stable v. Unstable Hierarchies

- Wild possums placed in triads (2 males, 1 female) and dominance hierarchies were formed
 - No difference in T at outset, but as formation progressed, subordinates dropped in T
- In triads after formation, half of the dominants were castrated, half were sham castrated
 - Castration had no effect on hierarchy

(Wehi, Barrell, & Hickling, 2006)

Evidence for T-Dominance link

Père David deer stags in Beijing Milu Park

- Harem leaders, Challengers, Bachelors
 - T was related to rank
 - Effectiveness of herding and mating related to rank
- Authors conclude mating behaviors are influenced by rank, which is influenced by T
(Chunwang, et al., 2004)

More Evidence

- Mandrills rising to alpha status showed increases in T, testicular size, and genital and facial red coloration (Setchell & Dixson, 2001)
- Controlling for age, T and social rank were correlated in chimpanzees, even during times of social stability (Muehlenbien, et al., 2004)
- Social rank was correlated with T, but not morphological traits (e.g. body mass) in mallards, wigeons, and pintails (Poisbleau, et al, 2005)

Experimental Evidence

- Castrated male mice were given either (physiological) high or low T treatment.
 - High-T dominated low-T mice in laboratory contests
 - In a quasi-field study (grass island on the highway) high-T mice had significantly higher survival rates than low-T mice

(Zielinski & Vandenberg, 1993)

Experimental Evidence

- Rats were either castrated, castrated+T, or sham castrated.
 - Castrated loss dominance, castrated+T and sham showed no change.
 - When castrated+T had their T-treatment removed and castrated were given T, dominance roles switched (Albert, et al., 1986)
- T-treatment increased dominance, aggression, and comb size in red grouse (Moss, 1979)

Mixed Findings

- T-dominance link found in finches in the laboratory, but not in field studies (Duckworth, et al., 2004)
- T was not related to dominance or aggression in male chimpanzees, only negatively correlated with aggression received (Klinkova, et al., 2004)
- T was not correlated to rank in vervets, but daily T fluctuations did predict daily changes in aggression (Steklis, et al., 1985)

T-Dominance in Humans

Differences between human and animal models

- Humans do not have a mating season
- Status hierarchies in humans are more complex
 - Individuals belong to multiple hierarchies
- Sex differentiation in humans v. rodents
 - In utero (humans) v. postnatal (rodents)
 - Role of aromatizing in masculinization of rodents does not translate to humans
- Dominance in humans rarely manifests itself as aggression

T-Dominance in Humans

- T is correlated to self-reported dominance
 - $r = .248, p \leq .05$ (Sellers, Mehl, & Josephs, 2007)
 - T has been shown to predict dominance related behaviors better than questionnaires (e.g. Josephs, et al., 2006)
- T was found to be correlated to conduct disorder via non-physical aggression and social dominance (Rowe, et al., 2004)

T-Dominance in Humans

- When T and status do not match, mismatch leads to emotional and physiological arousal, increased attention to status, decreased cognitive functioning (Josephs, et al., 2006)
- An analytic task completed by two subjects
 - Framed as competition: high-T outperformed low-T
 - Framed as cooperation: low-T outperformed high-T (Mehta, Josephs, & Wuehrmann, under review)

Need for Power and T

- Need for Power (nPow): A concern for having an impact on others (including holding higher status over them)
- Individuals high in nPow showed increases in T following an imagined competitive success and continued to show this elevation following a real competitive success (Schultheiss, et al., 1999)
- Following a power arousal film clip, nPow imagery in post-film PSE increased, as did T. The higher the pre-film nPow, the stronger the effect. (Schultheiss, Wirth, & Stanton, 2004)

Difficulties in studying humans

- Methodological restrictions
 - Questionnaire, saliva sample, manipulation/field study
 - Neuroscience methods?
 - Possible exogenous administration of hormones
 - Even this can be problematic (e.g. nasal oxytocin)

Difficulties in studying humans

- Disconnect between dominance and aggression
 - How do people express dominance non-aggressively?
 - Is aggression sublimated into prosocial behaviors?
(Dabbs, 1992; Dabbs & Morris, 1990)
 - Is it just dominance?
(Mazur & Booth, 1998)

Future Directions

- Endocrine profiles
- Expansion out of competition paradigms
(e.g. cooperation – Mehta, Josephs, and Wuehrmann, under review)
- Inclusion of other hormones besides T
(e.g. estradiol and power motivation in women – Stanton & Schultheiss, 2007)
- Prostate Cancer Patients and Androgen Deprivation Therapy